

The Analysis of the System of special water purification of Beloyarskaya Nuclear Power Plant unit BN-800

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Abstract. This article discusses how the latest system of special water purification KPF-30, designed specifically for the fourth power unit of Beloyarskaya nuclear power plant, which has a number of advantages over other water purification systems as chemical-physical and technical-economic, environmental, and other industrial indicators. The scheme covered in this article systems of special water purification involves the use of a hydrocyclone at the preliminary stage of water treatment, as a worthy alternative to ion-exchange filters, which can significantly reduce the volume of toxic waste. The world community implements the project of closing the nuclear fuel cycle, there is a need to improve the reliability of the equipment for safe processes and development of critical and supercritical parameters in the nuclear industry. Essentially, on operated NPP units, the only factor that can cost-effectively optimize to improve the reliability of equipment is the water chemistry. System KPF30 meets the principles and criteria of ecological safety, demonstrating the justification for reagent less method of water treatment on the main stages, in which no formation of toxic wastes, leading to irreversible consequences of environmental pollution and helps to conserve water.

1. Introduction

The water treatment system of nuclear power stations (NPS) is one of the most important systems that affect reliable, economical and safe operation of nuclear power plants. Since the commissioning of the first units to date, remains an urgent problem of creating and maintaining these chemical and physical properties of the coolant which would prevent corrosion damages of structural materials of equipment and deposits on its surfaces. On operated NPP units, essentially the only factor that can cost-effectively optimize to improve the reliability of equipment is the water chemistry. Conversely, the effect of the unreasonable water chemistry can have serious negative effects on the reliability and safety of NPP unit as a whole. Therefore, the system of special water treatment, nuclear power plants must meet high standards.

Currently, the world community implements the project of closing the nuclear fuel cycle, and development of critical and supercritical parameters in the nuclear industry, which will allow to solve



the problem of fuel starvation, due to the reprocessing of spent nuclear fuel nuclear power plants and to use in the future, the accumulated in reactor grade plutonium as fuel [1].

2. Main characteristics of BN-800

One of the major technical issues of nuclear energy is a reproduction of fissile fuel and nuclear power plant safety, disposal of radioactive waste over the lifetime of nuclear energy – have not yet found satisfactory solutions [2].

According to the energy strategy of Russia until 2020, the development of nuclear energy envisages the commissioning of the fast breeder reactor BN-800 and BN-1200. With the commissioning of this reactor type are associated hopes for nuclear fuel cycle closure based on the burning of weapon-grade plutonium mixed with uranium MOX (Mixed-Oxide fuel) is a fuel. The production of such fuel is soon to be established, and in 2020 possible demonstration of closed nuclear fuel cycle [3].

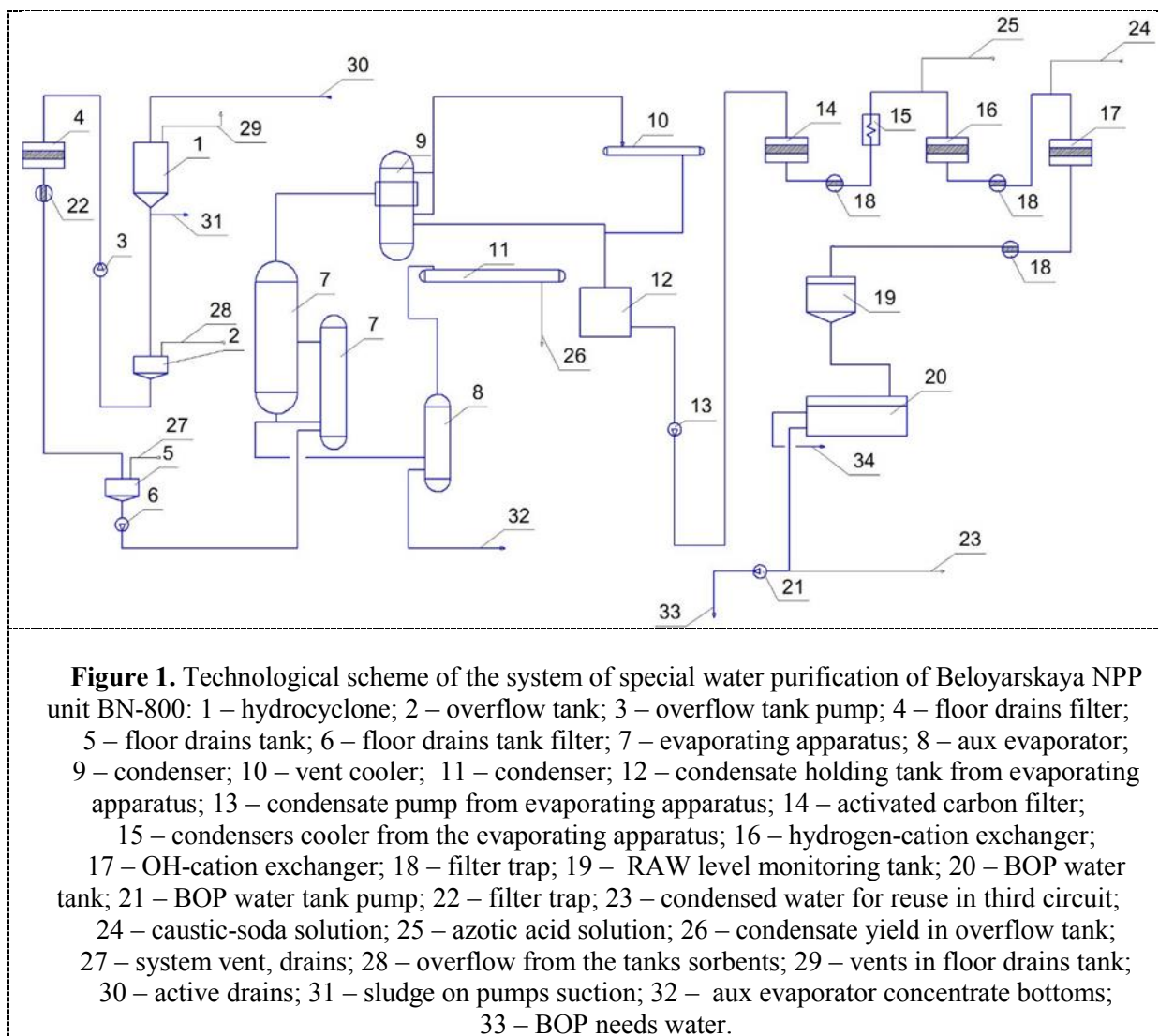
The BN-800 reactor is dual purpose layout integral fast reactor with liquid metal coolant, which is designed to generate heat energy for subsequent conversion into electrical energy in the composition of the unit and a result of secondary nuclear fuel [4].

3. Technical description of the system of special water purification

In the process of operating nuclear power plants generate liquid radioactive environs (hereinafter – iron ore) and liquid radioactive waste (hereinafter – LRW), which can be recycled at facilities of special water purification and storage of liquid waste obtained in the cured (air-conditioned) [5]. KPF30 system is designed to clean floor drain water by evaporation in combination with further purification of the distillate on ion-exchange filters. Is a unique technological solutions (has a high degree of automation, eliminated the human error factor), and has no analogues at the Russian stations [6]. As a method of purification adopted a two-stage evaporation dissolved solids floor drain water in the evaporator, and aux evaporator, allowing to obtain an optimum cleaning rate of the secondary pair. The secondary steam condensate is subjected to further purification on deoiling ion exchange filters. The system lifetime is 40 years.

The technological scheme is such: washing of the water and decontamination solutions from equipment of the reactor compartment from the collection unit and floor drain water from a floor drain sump water which need of purification are fed to the hydrocyclones. Under the action of centrifugal forces in hydrocyclones occurs initial purification from mechanical impurities, which is the accumulation of periodically brought into the collection container installation of casing. The clarified water enters the tank overflow, which produces water treatment for processing in an evaporation plant. If it is necessary, water tank overflow can be directed to cleaning the filters floor drain water for additional cleaning from mechanical impurities. The prepared solution from tank overflow is supplied in the heating chamber evaporator. Rising heating steam gives up heat to the solution, subsequently the solution boils. Vapor-liquid mixture from the heating chamber flows into the separator, where is the separation of vapor from the evaporated solution. Evaporated solution, due to the natural circulation from the lower part of the separator is re-circulated into the heating chamber where it is mixed with source water and boil. Secondary steam separated from boiling liquid is treated in a sieve-valve plates of the separator, spraying the phlegm, and fed to the condenser. The secondary steam condensate collected in the tank of the condensate, where the pump is pumped through the filters of post-treatment in the control tanks. After quality control, condensate evaporator is fed to the tank of own needs of the NPP. Evaporated solution of the cubic part of the evaporator is fed by gravity into the heating chamber of aux evaporator, where it is further concentrated. Upon reaching the permissible salt concentration of evaporated solution is periodically discharged into the tank intermediate storage of LRW. Secondary steam of aux evaporator after condensation in the condenser is discharged into the tank overflow. Non-condensable gases from the condensers are removed in secondary system gas purification. As a result of processing is obtained pure condensate that is re-used for own needs (water own needs) and for feeding the third circuit of the nuclear power station. The supporting of water

chemistry that affect safe, reliable and economic operation of nuclear power plants is a priority objective. KPF30 is able to provide a sufficiently high degree purification of different types of station water contaminated with nuclides and liquid radioactive waste, a variety of radioactivity, the volume and frequency of formation (fig.1).



High level of operational safety is achieved due to the installation of tanks with radioactive environments in the protective boxes. In case of spill water during emergency depressurization tanks, tanks building, pumps building, filters, floor drain waters lined with stainless steel 200 mm above the maximum level of protection.

System operation demonstrated the economic benefits of using in the first stage of cleaning (removal of mechanical impurities) a hydrocyclone. Hydrocyclones KPF51BB001, KPF52BB001 designed for cleaning floor drain water from the coarse particles and obtain clear water with a mass concentration of mechanical impurities not more than 250 mg/l required by the conditions of the evaporator. Technical characteristics of the hydrocyclones are shown in table 1.

Table 1. Technical characteristics of the hydrocyclones.

Characteristic	Value
Clarifying water, m ³ /h	20
Pressure of clarify water, MPa	<0,45
Pressure of compressed air, MPa	<0,8
Temperature, °C	
– under normal operating condition	30÷60
– in the period of dumping of the decontamination fluids	90
Salt concentration, no more g/l	5
Mass concentration of hard phase, mg/l	10÷1000
Particle size, µm	no more 1000
The main construction material	Steel 12Cr18Ni10Ti

As a result of processing is obtained pure condensate is re-used for own needs (water own needs) and feeding the third circuit of the NPP. For comparison, a special water purification of the Balakovo nuclear power plant the first stage carries out the ion exchange filters as a filter material using cation exchange resin [7]. The purchase of foreign reagents for filters is more expensive than the cost of electricity for own needs of the hydrocyclone.

This system of special water purification minimizes LRW, and has smaller volumes compared to other methods. Automated control system and control KPF30 provides high stability and serves to protect the system during abnormal operation and accidents [8].

KPF30 system and its components are able to work and perform their functions under seismic impacts up to the design-basis earthquake, inclusive. This system belongs to the class of repairable, restorable items.

4. Conclusion

System KPF30 meets the principles and criteria of radiation safety norms and rules, requirements of normative documents adopted in nuclear energy.

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